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TENSILE PROPERTIES AND MORPHOLOGICAL TEST OF HEAT CURED ACRYLIC RESIN REINFORCED BY NATURAL POWDERS

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ABSTRACT

In the present research, studying the effect of adding two different types of reinforcing particles, which included: Rice Husk and Bamboo powders which were practical size (25 and 75 µm) and utilize at four various concentrations of (2,4,6, and 8 wt.%), to locate improved in the properties of tensile for heat-cure acrylic resin. The blend of resin and powders were cured at temperature 70-100 °C in a water bath and 2.5 bar for 2hours, The ASTM D638 is used for composite specimens of the tensile test. The results showed that the strength of tensile and Young's modulus became better with low particle size and high concentration. Also, the results showed that the largest values of tensile strength and modulus of elasticity were (96 MPa.) and (1.85 GPa.) respectively when reinforced by Rice Husk powder at particle size (25 µm) and concentration (8 wt. %).

KEYWORDS: Rice Husk, Bamboo, Tensile, Heat Cure, Weight Fraction & Particle Size

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Original Article

INTRODUCTION

Many biomaterials are available in medicine and dentistry fields. Biomaterials can be classified as metals, polymers, ceramics and composites materials. Polymeric materials have many applications for implantation since they are available in a wide variety of compositions and properties [1]. The most common polymers used in biomedical and dentistry application are acrylic resin. In the 20th century, acrylic resin and other plastic materials were used in dental applications due to their attractive properties. Varieties of materials have been used in the fabrication of denture bases. Poly (methyl methacrylate) properties are modified when reinforced by adding many particles or fibers, this is the approach the scientist to research the effected of reinforced materials on the mechanical and physical features for the composite material [2]. The literature surveys include some researches, which are accomplished in this field, it's:

Hanan, A. et. al., (2013), investigated the effect of the reinforced by siwak powder with a size of the particle (75µm) in different weight concentrations on some mechanical characteristics of heat-polymerized PMMA. The results illustrated that any reinforcement of siwak powder to the PMMAless than 5% by weight the influence does not highly, the impact strength, compressive strength and tensile strength of the acrylic resin in comparison to the control group, while when addition powder of Siwak about (7 %) to the acrylic resin showed a considerable reduction in the strength of compressive, strength of impact and strength of tensile [3].

O. Eze et.al. (2013), estimated the effects of bamboo powder filler on some mechanical properties of recycled low-density polyethylene (RLDPE) composites were studied. The tests of mechanical which perform displayed that the strength of tensile reduces with increasing bamboo powder for recycled low-density

polyethylene specimens while the Young's modulus for the specimens rises with increasing the reinforcement [4].

M. Zurina et.al, (2004), Prepared Composites material from polystyrene/styrene butadiene rubber admixture and process rice husk powder then treated by esterification and acetylation. There was reduced in the strength of tensile, elongation at fracture and modulus of elasticity in treated rice husk powder samples [5].

Ahmad Bilal et.al, (2014) search the influence of Rice Husk (RH) component of the composites and Linear Medium Density Poly Ethylene (LMDPE) were applied with Maleic Anhydride Grafted Polyethylene (MAPE) on the mechanical properties. They showed that the properties of the composites (flexural and tensile) get better with a rise in the quantity of RH, whereas strength of Charpy impact reduces with rising fiber loading [6].

M. Ameen Khan et. al, (2017), study the addition of zinc oxide to the (PMM A) to the prepared composite material by using the process of melt mixing. PMMA composites made with different loadings of ZnO. The results showed that the composites tensile strength offer a slight reduces with a rise in ZnO content [7].

Jawad, K. Oleiwi et. al., (2013), studied the effects of the particles size and volume fraction of silica (SiO_2) ceramic particles on the mechanical characteristics of PMMA polymer. The results showed that the maximum shear stress, bending modulus, tensile strength, elongation percentage and modulus elasticity of PMMA composites is increased with increasing the addition of SiO_2 particles and with the increase in the loading filler ofSiO_2 particles. Also, the values showed that the impact energy and fracture toughness of PMMA composites decrease with rising in volume fraction SiO_2 particles. Silica particles with small particle size enhanced mechanical properties more than that of large particles size [8].

Sihama I. S. et. al. (2015), is studying the properties of PMMA by the addition of two types of particles nano-hydroxyapatite and micro-zirconia with different loading filler (1, 2 and 3 vol.%). The results show that the tensile strength of PMMA composites (PMMA-nHA), (PMMA-ZrO_2) and hybrid laminated composites specimens, increased with increasing of the volume fractions of (nHA) and (ZrO_2) particles [9].

Jawad K Oleiwiet. al (2017), studied the properties of PMMA when reinforced with a fiber of Siwak and improvement in the tensile properties. The fibers were cut into three lengths and used various concentrations, the results indicated that the tensile properties improved with the length if reinforcing fiber and loading fillers [10, 11].

MATERIALS AND METHODS

In this research, the composite prosthetic complete dentures specimens consist of a polymer matrix and reinforced powders materials. Matrix material included heat curing PMMA that used as fluid resin matrix, type (Spofa Dental Company)to preparation specimens of the composite prosthetic denture base. Two types of natural particles selected with a concentration of (2%, 4%, 6% and 8% wt.) and two particles sizes (25 and 75 µm) it was added to the acrylic powder including (Bamboo and Rice husk) powders. Figure 1 shows the two types of natural materials before and after grinding.

(a) **(b)**

Figure (1): (a) Bamboo Sample after Grinding, (b) Rice Husk Sample after Grinding.

The PMMA denture base materials consist of polymer powder and monomer liquid (methyl methacrylate, MMA). The standard proportion in mixing ratio for heat cure acrylic resin is usually volumetric ratio about (2.5) polymer powder (PMMA) and (1) monomer liquid (MMA). When mixing powder and liquid many changes will take place due to the solution of the polymer in the monomer. This ratio was an effect on the workability of the mixture, dimensional changes and toxicity of acrylic resin specimens [12]. The mold-pressed by using a metallic plate with a size similar to the size of the moldcavity, to obtain a smooth surface and to prevent gases vapor entry into PMMA during the curing. The mixture was covered in a closed container with pressure of about 2.5 bars. The curing process of acrylic was performed at conditions of (70ºC, 2.5 bar, and 30 min.) according to company instructions. And then raise temperature for around (30 min) to the (100 ºC) and stay at this temperature for one hour. Then the process of cooling the mold begins inside the curing device in order to remove the residual monomer.

Tensile Test

Tensile sample and test are carried out according to the standard specification of ASTM D-638 by using the global tensile device type (LARYEE) [13]. The rate of strain was (2 mm/min.). Figure 2 illustrates the sample for the tensile test which is standard. Figure 3 illustrates a sample of the composite.

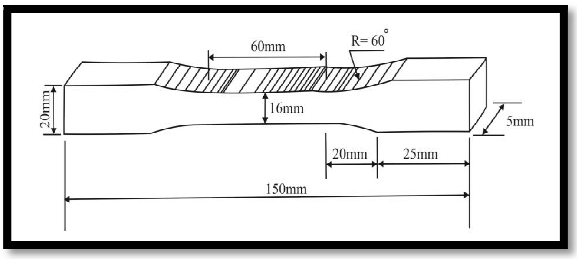


Figure 2: Tensile Test Specimen According to ASTM

Figure 3: Composite Specimens Before and After Test

RESULTS AND DISCUSSIONS

The samples of the composite with reinforcing particles (Bamboo or Rice Husk) have the larger strength to failure than pure PMMA because of the existence particles of reinforcing materials in PMMA thus certainly transference of loads from the matrix to powder.

Figures 4 and 5 notices the dependence on the tensile strength on weight fraction of (Bamboo, Rice Husk) powders in PMMA resin. The tensile strength values increased with rising of the weight fraction for both particles size of powders (25 and 75 µm). This is due to the strengthening and bond nature mentioned [13 and 14]. It can also be noticed that the tensile strength of (Bamboo, Rice Husk) with particle size (25 µm) it obtain tensile strength higher than particle size (75 µm) because amelioration of the mechanical properties that are related with the addition (25 µm)particles that related to the nature of particles which have high strength compared with (75 µm) particles.

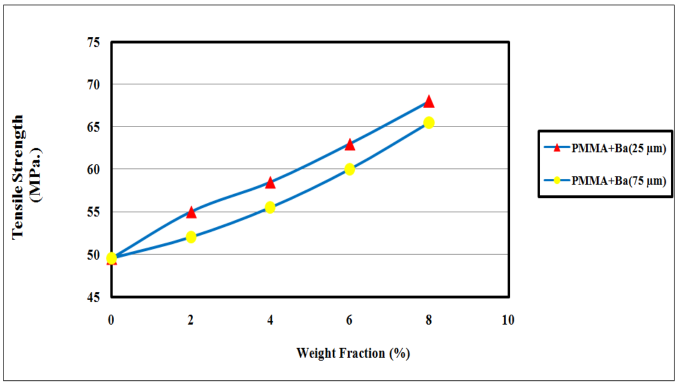


Figure 4: Tensile Strength and Weight Fraction of Bamboo Powders for PMMA Composite Specimens

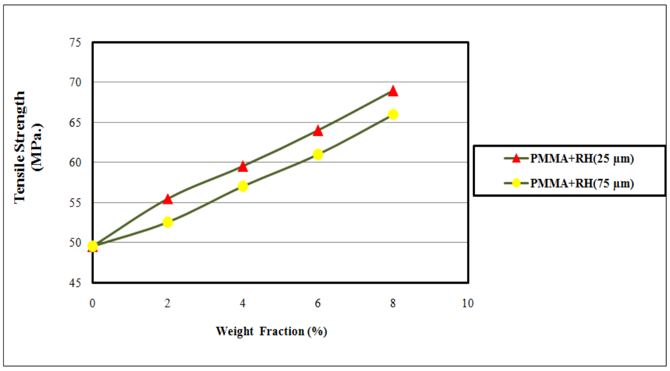


Figure 5: Tensile Strength and Weight Fraction of Rice Husk Powders for PMMA Composite Specimens

Figure 6 it can be seen the dependence of the tensile strength on maximum values of (Bamboo and Rice Husk) for both sizes at weight fraction (8%) compared with pure PMMA.

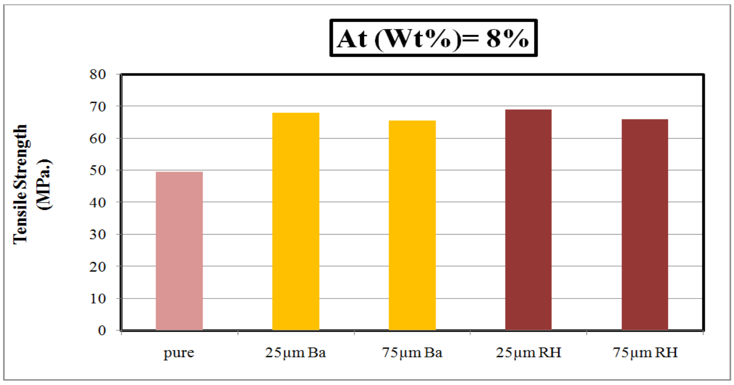


Figure 6: The Relationship between the Tensile Strength and Final Values of(Bamboo and Rice Husk) for Both Sizes at Weight Fraction (8%)

The addition of both types and size of particles resulted in a significant increase in the value of the tensile strength in comparison with the pure PMMA before adding process. Note that the highest value of tensile strength was obtained when adding Rice Husk of the particle size (25 µm) at a weight fraction of (8%). The maximum values of tensile strength (69 MPa.) were obtained at particle size (25µm) for rice husk.

Figures 7 and 8 illustrate the dependence of the modulus on elasticity and the weight fraction of the reinforcing (Bamboo and Rice Husk) powders in PMMA resin. The values of modulus of elasticity rise with increasing of the weight fraction for two particles size of (Bamboo and Rice Husk). This is due to the strengthening and bond nature mentioned [14 and 15]. Also because the powders have larger stiffness than matrix due to they have a modulus of elasticity larger than the matrix and that leads to enhancing the stiffness of the composite. Also the weight fraction of powders arise, there is a potential of powder-matrix interaction which leads to rising in activity of stress moving from the phase of the matrix to the phase of powder [16]. It can also be noticed that the modulus of elasticity with particle size (25 µm) it obtain modulus of elasticity higher than particle size (75 µm), this is due to the enhance of the mechanical properties that is related to the addition of (25 µm) particles that related to the nature of particles which have high strength comparing with (75 µm) particles.

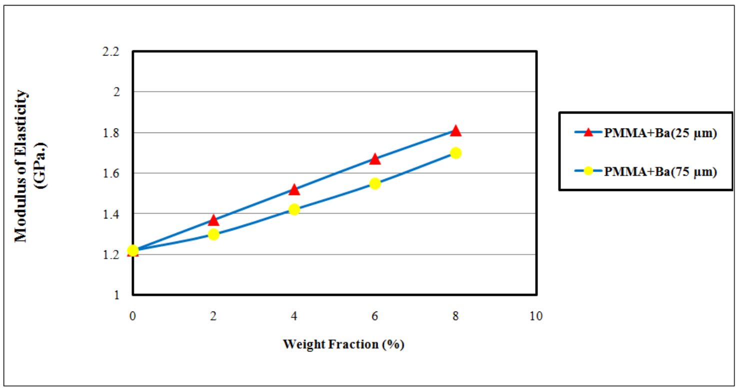


Figure 7: Modulus of Elasticity and Weight Fraction of Bamboo Powder for PMMA Composite Specimens

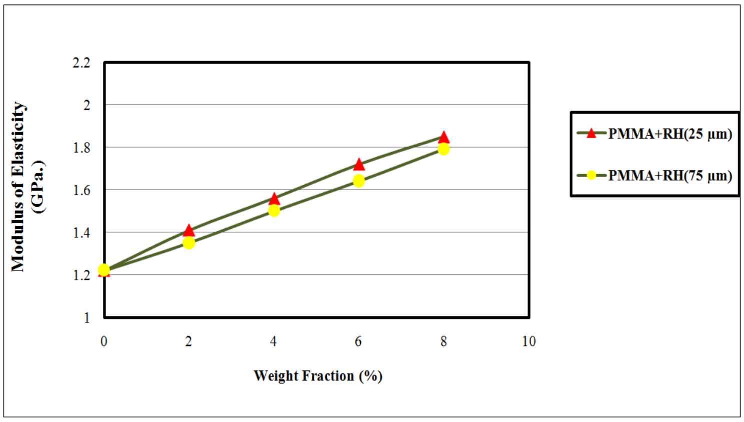


Figure 8: Modulus of Elasticity and Weight Fraction of Rice Husk Powder for PMMA Composite Specimens

Figure 9 it is clear the dependence of the modulus of elasticity on maximum values of (Bamboo and Rice Husk) for both sizes at weight fraction (8%) compared with unreinforced PMMA. The addition of both types and sizes of particles resulted in a significant increase in the value of the modulus of elasticity in comparison with the pure PMMA before adding process. Note that the highest value of modulus of elasticity was obtained when adding Rice Husk of the particle size (25 µm) at the weight fraction of (8%). The maximum values of modulus of elasticity (1.85 GPa.) were obtained at particle size (25µm) for Rice Husk.

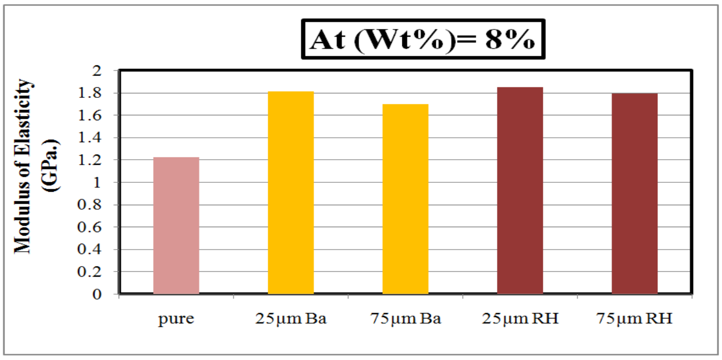
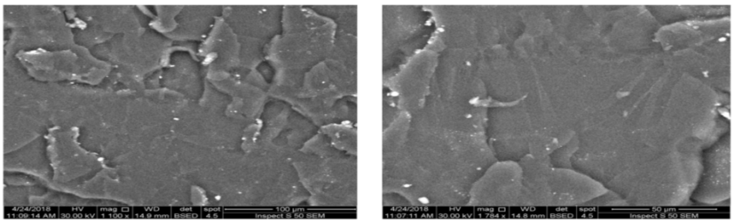


Figure 9: The Dependence of the Modulus of Elasticity on Maximum Values of(Bamboo and Rice Husk) for Both Sizes at Weight Fraction (8%)

In order to correlate the surface fracture morphology with mechanical properties of the PMMA as pure polymeric material and PMMA composite specimen, as a function of (Bamboo powders or Rice Husk powders) at different powders ratio content in composites. Scanning Electron Microscopy (SEM) was done on the fractured surface of the specimen of the tensile test after fracture. The properties of polymer composites strongly depend on their morphology. This is determined by the particles size, particle size distribution, particles shape, ratio of components [17 and 18]. The morphology of the fractured surface of the arranged PMMA sample, which it displayed at figure (10: a and b), could show a homogeneous morphology.

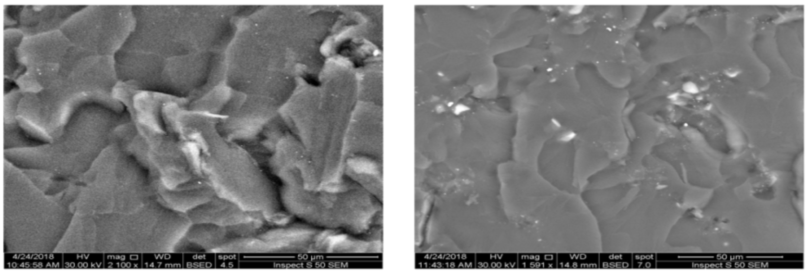


(a) 50µm (b) 100

Figure 10: SEM Image for Fractured Surface of Pure PMMA at Scale (a) 50 µm (b) 100 µm

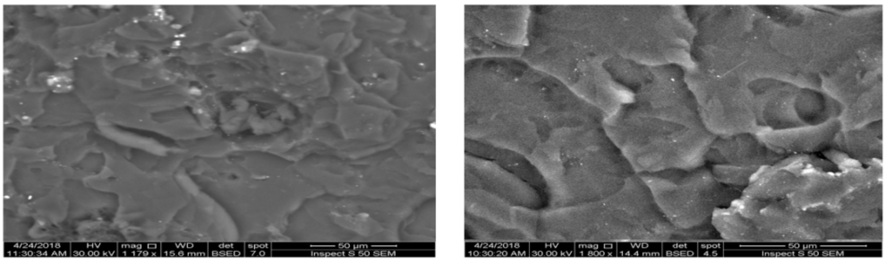
The fracture surface morphology of both systems, of Bamboo powders PMMA composite and Rice Husk powders PMMA composite reinforced by 8% (Bamboo and Rice Husk) ratio, are shown in figures (11: a and b) and (12: a and b) at the same magnification.

Furthermore, microparticles reinforcement of polymer can have different effects on polymer composites. The Two systems show a semi-continuous morphology. Also, this morphology shows the composite with Rice husk has high semi ductile than Bamboo powders PMMA composite which show have low semi ductile. On the other hand, the Bamboo and Rice Husk particles are homogeneously dispersed in the PMMA matrix of both systems, as well as these figures show the distribution of particles in semi-continuous morphology depending on the components of the PMMA composite. It was observed from figures that the dispersion of (Ba and RH) particles was relatively good and uniformly dispersed throughout the entire PMMA matrix. The SEM micrographs show the difference in the fracture surface morphology which depends on the components composite, the rough fracture surface of PMMA composites was changed due to the addition of natural powders, the fracture surface morphology of (PMMA- RH) composites much smoother fracture surface than (PMMA- Ba), it looks to be the best interfacial bond among all components of PMMA composite as compared with fracture surface morphology of the other material composite specimens that reinforcement with bamboo [19 and 20].



(a) Ba (b) RH with the Particle Size 25µm at Scale (50 µm)

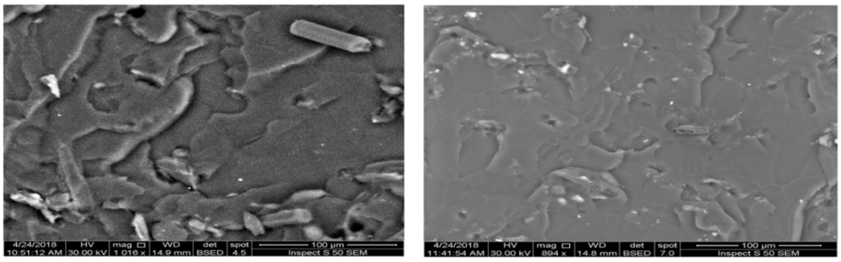
Figure 11: SEM Image of Fractured Surface Morphology of PMMA Composites Reinforced by (a) Ba and (b) RH with the Particle Size 25µm at Scale (50 µm)



(a) Ba (b) RH with the Particle Size 75µm at Scale (50 µm)

Figure 12: SEM Image of Fractured Surface Morphology of PMMA Composites Reinforced by (a) Ba and (b) RH with the Particle Size 75µm at Scale (50 µm)

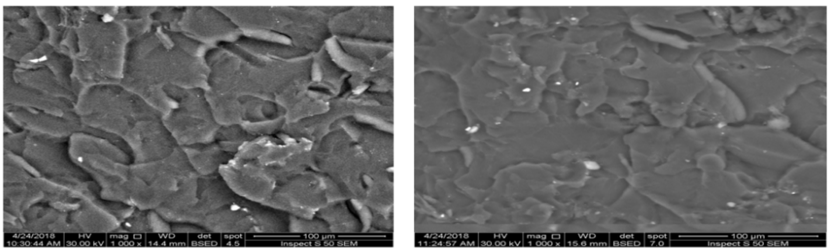
The fracture surface morphology of both systems, of Bamboo powders PMMA composite and Rice Husk powders PMMA composite reinforced by 8% (Bamboo and Rice Husk) ratio, are shown in figures (13: a and b) and (14; a and b)at the same magnification. Natural particles are homogeneously dispersed in the PMMA matrix. This is because the presence of the (Bamboo and Rice Husk) particles on the PMMA is likely to give the strong interfacial and interaction between the polymer matrix and the other phases (Bamboo and Rice Husk) powder in polymer composites. So the mechanical properties of the prepared composite increase when addition Bamboo powder and Rice Husk powder.



(a) Bamboo (b) Rice Husk with the Particle Size 25µm at Scale (100 µm)

Figure 13: SEM Image of Fractured Surface Morphology of PMMA Composites Reinforced by (a) Bamboo and (b) Rice Husk with the Particle Size 25µm at Scale (100 µm)

The PMMA composite reduction bring into being favorable, meanwhile this non-rigid performance avoid cracks formation so we will found a missing of tensile stresses at the matrix. No density gradients of models will detected at the cross segments analyses by SEM, displayed at all homogenous microstructure cases.



(a) Bamboo (b) Rice Husk with the Particle Size 75µm at Scale (100 µm)

Figure 14: SEM Image of Fractured Surface Morphology of PMMA Composites Reinforced by(a) Bamboo and (b) Rice Husk with the Particle Size 75µm at Scale (100 µm).

Also, observations that established at these composite systems were very compatible among the organic and inorganic components and the micrometer organic particles are well spread at PMMA matrix. In these figures, it was found that no characteristics of craze formation or growing. As an alternative, there is some of an essential mirror district, occasionally completed an inclusion might help by way of a failure initiation site, it was bounded within a fracture area [21].

CONCLUSIONS

A tensile strength and the modulus of elasticity increase by increasing the weight fraction of both types of powders (Bamboo and Rice Husk) in PMMA resin. The major value of tensile strength (69 MPa.) was obtained at particle size (25µm) for Rice Husk. The largest values of modulus of elasticity (1.85 GPa.) were obtained at particle size (25µm) for Rice Husk also. The fracture surface morphology of pure PMMA showed a homogeneous morphology in (SEM) test, even though the PMMA composite reinforced through bamboo or Rice Husk powders the fracture surface appeared semi-continuous region and not density gradients morphology, also appeared good compatibility between PMMA and other powders. Neither peak or peak shift founded with PMMA composite specimens by adding Bamboo or Rice Husk powders, also the increase in weight fraction of both types of powders lead to decrease the peak intensity to get the minimum value on 4%, when addition both type of natural powders (Ba and RH) at particle size (25 µm) and reach to the minimum value at (8 % wt.) when addition both type of natural powders (Ba and RH) at particle size (75 µm).

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